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PHOSPHORUS-COPPER RELATIONSHIP IN WHEAT*

by U. C. SHUKLA and NARENDRA SINGH**

Department of Soils, Haryana Agricultural University, Hissar

Key words

Crop yield Nutrient interactions Cereal crops

Summary

A green-house experiment was conducted to study P–Cu relationship in wheat variety S-308 grown up to maturity. Treatments included five levels, each of P (0, 25, 50, 100 and 250 ppm) and Cu (0, 2.5, 5, 10 and 50 ppm) in all possible combinations. The yield, P and Cu concentration were more with the application of Cu upto 5 ppm with P, and P upto 50 ppm with Cu, over P alone and Cu alone, respectively. Application of 50 ppm Cu adversely affected yield and P concentration and 250 ppm P adversely affected yield and Cu concentration. Application of affected nutrient counteracted to a great extent the adverse effect of the other nutrient. The low levels of P and Cu were essential for better plant growth and efficient utilization of both the nutrients and antagonism was noted only when one of the nutrients was applied in high quantities.

Introduction

Response to both Cu and P in wheat have been reported[4,5,10]. Some workers[1,4,6] reported decreased Cu concentration and uptake in wheat with high P. Whereas, others[2,3,11] found increased P concentration and uptake with Cu. These studies indicated the possibility of interactions between P and Cu in plants and as such more information is needed on this subject. Therefore, keeping the above in view, the present investigation was undertaken under green-house conditions using wheat as a test crop.

Materials and methods

A green-house experiment was conducted using polythene lined clay pots of 25 cm diameter filled with 4 kg of a loamy sand soil of pH (1:2), 8.0; O.C. 0.08%, E.Ce 0.98 mmhos/cm; C.E.C., 4.5 meq/100 g; $CaCO_3$ traces; available (Olsen extractable) P, 4.2 ppm; and available Cu (DTPA extractable) 0.31 ppm. Standard methods of soil analysis, except for Cu as described by Kanwar and

* Contribution from the Department of Soils, Haryana Agric. Univ., Hissar – India.

** Professor of Soils and Asstt. Soil Chemist, respectively.

Chopra[7] were followed for determination of above properties. Available Cu was determined in DTPA extract according to Lindsay and Norvell[9]. Treatments consisted of possible combinations of 5 levels of P, 0, 25, 50, 100 and 250 ppm as KH_2PO_4, and 5 levels of Cu, 0, 2.5, 5, 10 and 50 ppm as $CuSO_4.5H_2O$. Each treatment was replicated thrice in a randomized complete block design and received a basal application of N, K, Fe, Mn, and Zn at rate of 100, 30, 5, 5, and 5 ppm, respectively, through A.R. grade urea, KCl, $FeSO_4.7\ H_2O$, $MnSO_4.H_2O$ and $ZnSO_4.7\ H_2O$. Six plants/pot of wheat variety S-308 were grown upto maturity. The above ground plant parts were harvested and washed successively in distilled, acidified-deionized and deionized water twice and dried in an oven at 70°C after removing the excess water. The yield of grain and straw was recorded separately. The samples were ground in a stainless steel Wiley mill. For phosphorus and Cu determination, 0.5 and 0.2 g of each of straw and grain samples, respectively, were digested in conc. HNO_3 and $HClO_4$ mixture of 5:1 ratio. Phosphorus in the plant digest was estimated according to Koenig and Johnson[8]. Copper was analysed on a Varian Techtron atomic absorption spectrophotometer model No. AA 120.

Results and discussion

Straw and grain yield of wheat was affected by Cu and P levels and their interactions (Table 1). The application of Cu alone upto 5 ppm increased yield, whereas yield decreased with 10 and 50 ppm Cu. The yield with 50 ppm Cu was even less than in control (zero Cu and zero P). Similarly, yield increased with P upto 50 ppm, but decreased considerably with 250 ppm P though it was more than control. The application of Cu upto 5 ppm along with P increased yield at all levels of P. The highest yield both in grain and straw was noted when 5 ppm Cu was applied with 50 ppm P. The application of Cu more than 5 ppm decreased yield at P levels less than 50 ppm. The adverse effect of high Cu levels was neutralized with the application of 100 and 250 ppm P, particularly in case of grain. The magnitude of P response increased at high Cu levels due to the neutralization of the adverse effect of excess Cu. The results showed that a proper balance between P and Cu is necessary for maximization of yield. The yield patterns are in accordance with the soil

Table 1. Effect of different levels of P and Cu on straw and grain yield of wheat

Cu levels (ppm)	P levels (ppm)					Mean	P levels (ppm)					Mean
	0	25	50	100	250		0	25	50	100	250	
	Straw yield, g/pot						*Grain yield*, g/pot					
0	30.7	37.3	39.5	39.0	35.3	36.3	10.5	12.4	13.5	13.0	12.5	12.3
2.5	33.2	40.6	42.2	39.5	35.8	38.2	11.2	13.2	14.6	13.3	12.7	13.6
5	35.2	41.8	42.6	39.7	36.5	39.1	12.5	14.5	15.8	14.2	13.6	14.1
10	33.0	40.1	42.0	40.8	36.2	38.4	11.7	12.8	14.4	14.0	13.8	13.3
50	28.6	32.9	33.2	33.8	32.7	32.2	8.2	10.0	12.2	13.2	13.0	11.3
Mean	32.1	38.5	39.9	38.5	35.3		10.8	12.5	14.1	13.5	13.1	

	Straw	Grain
LSD ($P = 0.05$)	0.81	0.27
P	0.70	0.24
Cu × P	1.51	0.46

Table 2. Effect of different levels of P and Cu on Cu and P concentration in wheat straw and grain

Cu levels (ppm)	P levels (ppm) 0	25	50	100	250	Mean	P levels (ppm) 0	25	50	100	250	Mean
	Cu concentration in straw (ppm)						*P concentration in straw* (ppm)					
0	4.3	4.9	5.2	5.0	4.5	4.7	875	1587	1837	2287	2625	1842
2.5	5.8	6.5	6.2	5.7	5.1	5.8	937	1962	2087	2475	2625	2017
5	6.6	6.8	6.8	6.3	5.8	6.4	1086	1982	2137	2475	2600	2054
10	8.5	7.6	6.0	6.0	6.0	6.8	1082	1982	2087	2202	2575	1985
50	12.6	12.8	10.8	10.1	8.2	10.9	987	1705	1962	2135	2437	1845
Mean	7.5	7.7	7.0	6.6	5.9		993	1843	2022	2314	2572	
	Cu concentration in grain (ppm)						*P concentration in grain* (ppm)					
0	5.6	6.0	6.9	6.0	4.6	5.8	1437	2050	2712	3025	3750	2594
2.5	7.5	9.1	8.2	7.3	6.2	7.6	1625	2562	3040	3337	4062	2925
5	10.2	10.2	9.8	9.0	6.2	9.0	1687	2662	3250	3425	4062	3017
10	13.4	13.8	13.0	11.6	8.1	11.9	1687	2605	3187	3312	4006	2959
50	18.6	19.3	19.3	15.2	13.5	17.1	1172	2136	2775	2876	3912	2574
Mean	11.0	11.6	11.4	9.8	7.7		1521	2403	2992	3195	3958	

LSD ($P = 0.05$)	Straw	Grain	Straw	Grain
Cu	0.35	0.08	32.0	56.0
P	0.21	0.06	22.0	46.0
Cu × P	0.92	0.27	46.0	92.0

status for P and Cu, which was marginally deficient in both the nutrients. Therefore, responses when they were applied individually at low levels were not unexpected.

Copper concentration in wheat grain and straw increased with increasing levels of Cu at all the levels of P (Table 2). The proportionate increase was more in grain than in straw. The application of 25 ppm P generally increased Cu concentration. The addition of P beyond 50 ppm decreased Cu concentration in grain and straw. The decrease in concentration was more pronounced with the application of 250 ppm P compared to 25 ppm P. On an average the decrease was about 30% with 250 ppm P compared to zero P level at 50 ppm Cu. The results thus showed the reduced absorption and/or translocation of Cu from soil in the presence of high P. Since soil pH was conducive to the formation of $Cu_3(PO_4)_2$, therefore, the decreased availability in soils at higher P levels could not be ruled out. Besides the decreased Cu availability in soil, the interaction at absorption sites and during translocation from root to shoot could also be expected. However, the results also indicated that low levels of P were essential for utilization of Cu. The results were similar to the findings of Hilka[6] in oats and Bamhroliya *et al.*[1] in wheat.

Phosphorus concentration in straw and grain of wheat increased significantly with increasing level of P. The proportionate increase was more with 25 ppm P. Phosphorus concentration also increased with Cu upto 5 ppm. However, the concentration decreased with a further increase in Cu level to 50 ppm regardless of P level. The proportionate decrease was more at zero P level. The reasons for this decrease in concentration of P at higher levels of Cu could be the same as discussed for adverse effect of high P on Cu. The interaction within plant and at the absorption sites could be physiological in nature as low levels of Cu were apparently essential for efficient utilization of P by the plant and *vice-versa*. These results are in agreement with the findings of Bingham[1], Dakhore *et al.*[3] and Younts and Patterson[11] who suggested Cu stimulated P absorption due to some reactions outside the root.

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